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ABSTRACT

This study sought to answer the question, Do all students benefit equally from the use of a hypermedia Goal-Based Scenario (GBS)? GBS is a subcategory of anchored instruction. The correlation between the demographic variables and achievement and specific cognitive variables and achievement was explored using a lesson on DNA, and was tested on different populations using a multimedia GBS on a group of introductory biochemistry classes with a pre- and post-test content. The study used laboratory activities and simulations via a Web-based classroom management system (WebCT) on learning. This study demonstrates that GBS is equally effective for all students and may, therefore, be effective with students traditionally underserved by conventional methods of instruction without negative effects on the majority. This type of instruction is also determined to be clearly more beneficial to students possessing the formal reasoning skills necessary to investigate and develop hypotheses in scientific settings. The Purdue Visualization of Rotations Test (ROT), the Test of Logical Thinking (TOLT), and the Hidden Figures Test (HFT) were used as cognitive evaluations. (Contains 21 references.) (YDS)

Relation of Student Characteristics to Learning of Basic Biochemistry Concepts From a Multimedia Goal-Based Scenario

by
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Objectives

The overall goal of this study was to answer the question: Do all students benefit equally, from the use of a hypermedia Goal-Based Scenario (GBS)? To accomplish this goal, a multimedia GBS lesson on DNA was tested with different populations in order to explore the correlation between demographic variables and achievement, and specific cognitive variables and achievement. The demographic characteristics were chosen in an attempt to examine the performance of traditionally underrepresented groups, while the cognitive characteristics were chosen because previous studies (e.g., Lawson, 1983; Niaz & Lawson, 1985; Mitchell & Lawson, 1988; Staver & Jacks, 1988; Zeitoun, 1988; BouJaoude & Guiliano, 1994) have shown that certain cognitive characteristics are correlated with science achievement. Specifically, three research questions were explored:

1. Is there a relationship between demographic variables (gender, race/ethnicity, final score in current chemistry course and prior coursework in science) and learning outcomes from a multimedia GBS lesson on DNA?
2. Is there a relationship between prior experience with computers and learning outcomes from a multimedia GBS lesson on DNA?
3. Is there a relationship between cognitive abilities (logical thinking, spatial ability and disembedding ability) and learning outcomes from a multimedia GBS lesson on DNA?

Theoretical Framework

Anchored instruction is an instructional technique in which concepts are taught by presenting them in a macro-context or practical situation. The presentation strategy allows for an immediate application of the new knowledge, and should facilitate integration of this new information into students' existing cognitive structures. This context can take many forms, such as the stories used in the Jasper Woodbury (Cognition and Technology Group at Vanderbilt, 1993) or the simulated "real-life" situations used in Goal-Based Scenarios (Schank & Cleary, 1995). Goal-Based Scenarios are a sub-category of anchored instruction. The distinction between Goal-Based Scenarios and Anchored instruction is that the former require the student to be an active participant in the scenario or context, while the latter simply requires that material be presented within a context. Kolodner (1993) stated that Goal-Based Scenarios are an effective teaching tool because they can be used to create learning situations in which "**everybody** learns--not only students for whom the traditional styles of learning come easy" (p. 304). Schank and colleagues (1993) state that Goal-Based Scenarios are an effective approach to teaching because "the underlying principles of Goal-Based Scenarios are founded on a sound theory of memory and learning" (p. 340).

The multimedia unit used in this study was constructed by the researcher in the form of a hypermedia-delivered Goal-Based Scenario, following the design principles outlined by Schank et al. (1993). The structure and scenario are analogous to those of Sickle Cell Counselor (Bell, 1994; Bell et al., 1993a, 1993b), a hypermedia Goal-Based Scenario currently on exhibit at the Museum of Science & Industry in Chicago, IL. The Mission Context for the lesson on the structure and properties of DNA is a murder mystery. This context provides a credible cover story within which students can acquire the target skills and practice them in a simulated realistic setting.

The design of "Whodunnit?" supports learning as described by constructivist theories. Students may begin their exploration from any point within the GBS and branch out to other areas based on their personal preferences, which will undoubtedly be influenced by prior knowledge. "Whodunnit?" also supports the interrelation of new cognitive nodes because all of the important concepts are presented at least twice, in slightly different contexts.

Certain demographic characteristics have been consistently associated with science achievement. A review of the literature documents a substantial gap in science achievement between men and women and between minority and majority ethnic groups. Some proposed explanations for these differences include (a) lack of role models, (b) developmental differences in spatial abilities, and (c) the effects of home environments and differential socialization (Kahle, 1984) but a definitive cause-effect relationship has not been established.

Description of Study

A multimedia GBS, "Whodunnit?," was developed to teach concepts related to DNA and DNA fingerprinting. The target audience is students in introductory biochemistry classes. 'Whodunnit?" is an "investigate and decide" type of GBS, in which students are asked to analyze a set of information and then come to a conclusion based on the evidence. In this case, a real-life application of forensic chemistry is dramatized. Students are cast in the role of outside experts called in to assist local authorities in solving the murder of a biochemistry professor.

Content pre- and post-tests, in the form of a quiz on the concepts presented in "Whodunit?" were administered to students enrolled in the second semester of introductory chemistry courses for non-majors. Data was gathered on students' cognitive skills (spatial ability, logical reasoning skills, disembedding ability) by having participants complete the Purdue Visualization of Rotations test (Bodner & Guay, 1997), Test of Logical Thinking (Tobin & Capie, 1981), and Hidden Figures Test (Ekstrom et al., 1976) prior to participating in the study. Demographic variables (gender, race/ethnicity, prior computer use/experience) were assessed via a questionnaire developed by the researcher. Final course scores were obtained directly from cooperating instructors.

Demographic Variables

Subjects for this study were students enrolled in second semester introductory biochemistry courses at four participating institutions in the U.S. and Canada. A total of 525 students participated. These students represented a variety of educational settings, ranging from a small community college in a rural area to a large private university in the heart of a bustling city. Of these 525 students, 37 formed a pseudo-control group, and 488 received the experimental treatment. The majority of the experimental subjects came from Institution C ($\underline{n}$ = 248, 50.8%). Institution A provided a number of subjects ($\underline{n}$ = 98, 20.1%) almost equal to that of Institution C ($\underline{n}$ = 87, 17.8%). The remainder of the experimental subjects were students from Institution D ($\underline{n}$ = 55, 11.3%). Within the experimental group, 212 subjects (43.4%) were male and 263 (53.9%) were female. Thirteen subjects (2.7%) did not indicate their gender. The control group consisted of 10 (27.0%) male students, 26 (70.3%) female students and one (2.7%) student who did not indicate gender.

The majority of students (74.7%) in both treatment conditions reported their ethnicity as White/non-Hispanic. In the experimental group, 362 students (74.2%) identified themselves as White, 12 (2.5%) selected African-American as their ethnicity, 8 students (1.6%) represented themselves as Hispanic, 21 (4.3%) chose Asian/Pacific Islander as their ethnicity, one student (0.2%) reported being of Native American ancestry and 19 students chose "other" as their ethnicity. Sixty-five students did not specify ethnicity. Only three ethnic groups were represented in the control group. Thirty students (81.1%) in this group identified themselves as White, two students (5.4%) selected Asian/Pacific Islander as their ethnic group and one student (2.7%) reported being of African-American ancestry. One student (2.7%) chose "other" to represent ethnicity, and three students (8.1%) did not respond to this question.

Most students in the experimental group ($n = 164$, 33.6%) were college seniors. Juniors were the next largest group ($n = 141$, 28.9%), followed by Sophomores ($n = 114$, 23.4%), Freshmen ($n = 48$, 9.8%) and Graduate/non-degree students ($n = 6$, 1.2%). Fifteen students in the experimental group did not specify their year in college. In the control group, the majority of students were Sophomores ($n = 15$, 40.5%). Juniors made up the next largest group ($n = 11$, 29.7%). There were no Freshman or Graduate/non-degree students in the control group, and one student (2.7%) did not respond to the question.

The majority of students were enrolled in their chemistry class because it was a requirement ($n = 401$, 82.2% for the experimental group, $n = 34$, 91.9% for the control group). Of the remaining students in the experimental group, 11 (2.2%) were taking chemistry as an elective, 37 (7.6%) were taking it to fulfill general education requirements and 39 (8.0%) did not specify a reason. In the control group, one of the remaining students (2.7%) reported taking the course to fulfill a general education requirement and two students (5.4%) did not specify a reason. In the experimental group, students reported completing an average of 3.73 ($SD = 1.73$) science courses and 1.29 ($SD = 0.84$) chemistry courses in high school. These students also reported an average of 3.76 ($SD = 3.68$) prior science classes and 1.60 ($SD = 1.48$) prior chemistry courses in college. In the control group, students reported completing an average of 3.37 ($SD = 1.31$) science courses and 0.91 ($SD = 0.52$) chemistry courses in high school. The average number of prior science courses taken in college was 2.71 ($SD = 1.89$) for this group, and the average number of prior chemistry courses was 1.26 ($SD = 0.61$).

At the time of the survey, 328 students (69.2%) in the treatment group reported owning a computer, while 146 (30.8%) did not. In the control group, 21 students (58.3%) stated that they did own a computer, and 15 participants (41.7%) stated that they did not. In the experimental group 62 students (13.3%) stated that they rarely used a computer, while 5 students (13.9%) in the control group reported rarely using a computer. A sizable number of students in the experimental group, (142, 30.4%) reported occasional use of a computer, and an almost equal proportion of students (25.0%) in the control group reported occasional computer use. In both groups, the majority of students reported frequent use of a computer (263 students, 56.3%, for the experimental group; 22 students, 61.1% for the control group). It is important to note that while almost all participants had some degree of experience using computers, only 30 students (6.3%) in the experimental group and 3 students (8.3%) in the control group reported using a computer to access scientific tutorials. Thus, very few students in either condition were accustomed to using computer-based instruction in the sciences.

Cognitive Variables

The Test of Logical Thinking, TOLT (Tobin & Capie, 1981) was used to assess students' formal reasoning ability. TOLT is a ten-item paper and pencil test designed to measure five modes of formal reasoning: controlling variables, proportional reasoning, combinatorial reasoning, probabilistic reasoning and correlational reasoning. Each of these modes is measured by two test items. In order for a response to be considered correct, students must select both the correct answer and its justification from five alternatives. The Hidden Figures Test (CF-1) is an ETS adaptation of the Gottschaldt Figures Type test. This test measures students' ability to disembed relevant information from an irrelevant background. It is a timed test, consisting of 32 items in which students are asked to decide which of five geometrical figures is embedded in a complex pattern and outline it. The authors state that this test has a level of difficulty suitable for grades 8-16. The Purdue Visualization of Rotations Test (ROT) is a 20-item test in which students are asked to predict how an object will look after it has been rotated in the same manner as a sample object. This test probes students' problem solving ability and measures the students' ability to abstract relevant information from two-dimensional models projected on a computer screen.

The instrument used as both a pre- and post-test was a multiple-choice test, with answer foils being taken from incorrect student responses during a pilot study. The content test consists of 14 multiple-choice items measuring students' knowledge of material presented in "Whodunnit?" Since some test items require students to select more than one response, each correct response was given a value of one point, for a total of 25 possible points.

Implementation Method

Cognitive tests (ROT, TOLT, and HFT) and a demographic questionnaire were administered to participating subjects during a regularly scheduled lecture session, prior to the treatment. Regardless of treatment condition or location, all subjects were given the same amount of time to complete each cognitive and content test. Students were given 10 minutes to complete the ROT (Bodner & Guay, 1997), 24 minutes to complete the HFT (Ekstrom et al., 1976) and 15 minutes to complete the TOLT. Administration times for both the pre- and post-tests were set at 20 minutes each. A test administration script was employed at each site, in order to ensure consistency in testing conditions.

All students were given a lab report form to complete while going through the multimedia lesson. Content post-tests were administered to all students under proctored conditions after they had completed the unit.

Due to academic scheduling constraints, there were minor variations in administration details at each site. However, threats to validity were minimized by ensuring that all personnel followed the same test administration script. The researcher was present for all investigations taking place at Institution A. A preliminary visit was made to participating classes at Institution A during a regularly scheduled lecture period in order to give a brief introduction to the study and obtain student consent. All three cognitive tests were administered to the entire class, during a regular lecture period, approximately 1-6 days prior to their use of "Whodunnit?" During the treatment week, the researcher visited each of the laboratory sessions to administer the pre-test. All students, including those choosing not to participate, were required to complete the pre-test as a "quiz" that was part of their laboratory assignment. However, they were told that their grade would be based on completion of the "quiz," instead of on actual performance. Upon completion of the pre-test, students were led to the computer lab, where the researcher presented an introduction to the unit, explaining the role students were to assume during the instruction.

Instructions on how to navigate the simulation were also give at this time. Students were then allowed to proceed through the instruction at their own pace. After they completed the unit, they were asked to turn in the demographic survey. The post-test was administered during the last 20 minutes of the lab period.

The researcher visited Institution B, where she was present for the administration of cognitive tests to all participants. However, since students attend lab on alternating weeks, it was only possible for her to supervise the experimental treatment for those subjects attending lab the week of her visit (approximately 50%). Teaching Assistants (Tas) from Institution B assumed the role of students while participating in the instruction supervised by the researcher. After this experience, the TAs received instruction in administering the treatment and pre- and post-tests. The following week, the TAs supervised the remaining laboratory sessions and were responsible for administration of the pre- and post-tests. Aside from these modifications, all other administration procedures were the same as for Institution A.

A slightly different procedure was employed for each of the participating sections at Institution C. In the case of Biochemistry 100, the experimenter was able to travel to the site and personally administer the cognitive test and content pre-test. Due to scheduling constraints and the need to modify test distribution and collection procedures to ensure individual accountability in a very large lecture session while still maintaining subject confidentiality, two consecutive lecture periods were dedicated to the study. An introduction to the study was given during the first period, and students were asked to complete and return the consent forms. Once this was accomplished, the TOLT and ROT were administered according to the test administration script. The following lecture period was devoted to administering the HFT and content pre-test and to providing instructions to students on how to access "Whodunnit?" Since there were no laboratory sessions associated with this class, the simulation was made available to the students via WebCT (a web-based classroom management system), in order to allow the instructor to track student usage. The researcher was in e-mail contact with the instructor during the following week as students were allowed free access to the software. Students were expected to complete the computer-based instruction, the lab report form and the reaction questionnaire during this time. After a week had elapsed, the course instructor administered the post-test during a lecture session, and collected all remaining materials.

Since the researcher was not able to travel to Institution C a second time, the instructor for BCH 105 assumed responsibility for administering all tests and treatment, following scripts supplied by the researcher. Two cognitive tests (HFT and TOLT) were administered during course recitation sections that met at various times over the course of one week. The (ROT) and content pre-test were administered to the class as a whole during the first lecture immediately following the recitation sections (on a Monday). Demographic surveys and consent forms were collected during this period and the instructor explained how to access "Whodunnit?" The program was then made available to students over the next four days (Monday – Thursday), during which time they needed to complete the instruction, lab report and reaction questionnaire. The content post-test was given to the whole class, during the next lecture session (on Friday), at which time the instructor collected all materials and shipped them to the researcher.

All testing at Institution D was supervised by the class instructor, following the same procedures and scripts used at Institution A.

Results and Conclusions

An alpha value of 0.05 was selected as the criterion for significance in all hypotheses tested in this study. Due to the large sample size ($n = 488$) the risk of type II error is minor, so a 5% risk of a type I error was accepted. The first test employed was a paired comparisons t-test in order to determine if there were significant differences between pre- and post-test scores. Due to the difference in sample sizes among the different ethnic groups, the relationship between demographic variables (gender, race/ethnicity, course rank, prior chemistry coursework) and achievement was explored using general linear models, followed by a more in-depth examination of the impact of course rank. A Tukey's Studentized Range (HSD) test was conducted on the post-test scores, in order to determine if there were any differences among mean post-test scores within any of the quartiles. Because of inconsistencies in the manner in which prior coursework was reported (semester vs. quarter hours), all numerical values for this variable were converted to Z scores (a measure of deviation from the mean) before inclusion in the analysis. Linear regressions were used to examine the relationship between cognitive variables and achievement, using pre-test as an independent variable.

In the experimental group, 458 students completed both the pre- and post-tests. These 458 scores were examined using a paired comparisons t-test to determine if a significant difference existed between each set of scores. Pre-test scores ($n = 469$) for the experimental group ranged from 0 to 21.0, with a mean of 10.05 ($SD = 3.97$). Post-test scores ($n = 467$) for the experimental group ranged from 0 to 25.0 with a mean of 14.95 ($SD = 4.73$), for an average gain of 4.90 points out of 25. The mean scores ($n = 458$) for students who competed both tests were significantly different from each other at the $p = 0.0001$ level ($t = 24.30$). In the control group, 26 students completed both tests. Student scores on the pre-test ranged from 4.0 to 19.0, with a mean of 9.92 ($SD = 3.30$). Post-test scores for the control group ranged from 5.0 to 21.0, with a mean of 10.88 ($SD = 3.20$), and an average gain of 0.96 points. These mean scores (pre- and post-test) were not significantly different from each other at the $p = 0.05$ level ($t = 1.74$, $p = 0.0945$).

The contribution of demographic factors to learning was examined via a general linear model. This procedure determined that pre-test scores were the best predictor of post-test performance, accounting for the largest portion of total variance in post-test scores ($F = 93.84$, $p = 0.0001$). The next largest portion of variance was accounted for by the standardized number of science courses taken in high school ($F = 12.64$, $p = 0.0004$), with greater numbers of science courses taken corresponding to higher post-test scores. Gender ($F = 3.86$, $p = 0.0501$), ethnicity ($F = 0.33$, $p = 0.9194$) and numbr of science courses taken in college ($F = 1.27$, $p = 0.2603$) did not contribute significantly to the model. Even though two independent variables (pre-test scores and number of high school science courses) made statistically significant contributions to the general linear model, the overall amount of variance that could be explained by these variables was only 31.2% (R-Square = 0.311574). The practical significance of this relationship is minimal.

Final scores obtained by students ($n = 393$) in their current chemistry course were grouped into quartiles, and the general linear model was applied using these quartiles as categorical variables, with a total of 369 observations (due to missing pre- and post-test values). Once again, pre-test scores accounted for most of the observed variance ($F = 70.29$, $p = 0.0001$). Since a significant relationship was found between course rank (quartile) and post-test score ($F = 3.44$, $p = 0.0171$), a Tukey's Studentized Range (HSD) test was conducted for the post-test variable, in order to determine if there were any differences among mean post-test scores for any quartile. The test revealed that the difference between mean post-test scores for students in the upper quartile (Q4) and students in Q1, Q2 and Q3 was statistically significant at the alpha = 0.05 level (confidence = 0.95, df = 364, MSE = 16.56). The mean post-test score for students in Q3 was not significantly different from the mean post-test scores for students in Q2 and Q1. Likewise, the mean post-test score for students in Q2 was not significantly different from the mean post-test score for students in Q1. Both variables tested in this model (course rank and pre-test score) were found to be important predictors of post-test score. When taken together they accounted for 21.6% (R-Square = 0.215892) of the observed variance. However, as the majority of the explained variance was attributed to the pre-test (pre-test scores accounted for 27% of variance in post-test scores when entered as the only independent variable in the model), the researcher concludes that course rank is not a significant predictor of learning outcomes from a multimedia GBS on DNA fingerprinting.

A general linear model was used to examine the relationship between learning outcomes and technology use. Post-test score was used as the dependent variable, and computer ownership, frequency of use, total number of applications used and use of scientific tutorials as the model variables. Computer ownership accounted for the largest portion of variance in post-test scores ($F = 10.13$, $p = 0.0016$). Prior use of scientific tutorials made a significant contribution to this model ($F = 8.59$, $p = 0.0036$), as did total number of applications used ($F = 4.81$, $p = 0.0288$). Reported frequency of computer use was not found to contribute significantly to the model ($F = 3.30$, $p = 0.0698$). The total amount of variance in post-test scores explained by the significant variables was only 5.6% (R-Square = 0.056381). Therefore, the researcher failed to reject the null hypothesis and concluded that there is no relationship between prior experience with computers and learning outcomes from a multimedia GBS lesson on DNA.

Logical thinking skills were the only cognitive characteristic found to correlate with learning in this medium. Pre-test scores and final grades obtained in the course in which the study took place were also significant predictors of post-test achievement, but together they accounted for less variation in post-test scores than logical thinking alone. A general linear regression model demonstrated that student scores on the pre-test and TOLT accounted for the largest portion of the observed variance in post-test scores (R-Square = 0.3015). Based on these results, a second regression procedure, forward selection, was carried out. Pre-test scores were found to account for the largest amount of variance explained by the model ($F = 164.11$, $p = 0.0001$, partial $R^2 = 0.2708$). Student scores on the TOLT also made a significant contribution to the explained variance ($F = 15.3210$, $p = 0.0001$, partial $R^2 = 0.0245$). Student scores on the HFT ($F = 2.0035$, $p = 0.1576$, partial $R^2 = 0.0032$) and the ROT ($F = 1.8980$, $p = 0.1690$, partial $R^2 = 0.0030$) did not contribute significantly to the regression equation. The total amount of variance in post-test scores explained by both significant variables (pre-test and TOLT) was only 30.2% (R-Square = 0.3015), and the majority of this variance (27.1%) was due to the pre-test scores. Therefore the practical applications of this relationship are highly limited, as TOLT scores accounted for only 2.5% of the observed variance in post-test scores. This researcher concluded that there is no significant relationship between two cognitive abilities (spatial ability and disembedding ability) and learning outcomes from a multimedia GBS lesson on DNA, but that logical thinking ability is a valid, although weak, predictor of learning outcomes from a multimedia GBS lesson on DNA.

Educational Implications

Numerous studies have been carried out to determine if the use of technology enhances learning of chemical concepts (e.g., Moore, Smith, & Avner, 1980; Jackman, Moellenberg, &

Brabson, 1987; Smith & Jones, 1989; Geban, Askar, & Ozkan; 1992) but none of these studies have focused on differential effects which the technology may have on students of simultaneously varying ability levels and demographic characteristics. Those that have examined any differential effects, such as Harwood and McMahon (1997) have investigated the effects of a cognitive variable (logical thinking) on learning from media. Lagowski & Calvin (1978) examined the effects of computer simulations on the performance of high and low aptitude students.

Research conducted on the effectiveness of Goal-Based Scenarios (Bell, Bareiss & Beckwith, 1993a, 1993b; Bell, 1994) has documented positive outcomes, such as higher achievement and an increased ability to learn under what conditions particular knowledge is appropriate and when it may be transferred to new situations. However, there have been no published studies to date investigating the claim that all students benefit equally from the use of GBSs. In fact, none of the published articles contained a detailed demographic analysis of the participants, making it impossible to determine if there is any correlation between demographic variables and student outcomes. No studies regarding the use of GBSs in chemistry teaching have been reported in the literature.

This study demonstrates that Goal-Based Scenarios are equally effective for all types of students. Therefore it may be possible to use this type of instruction to reach students from groups that have been traditionally under-served by conventional methods of instruction, without negative effects for the majority. Some question remains as to the effectiveness of GBSs as remedial instruction in science, because of the correlation between achievement in this medium and logical reasoning ability, as well as grades. This type of instruction is clearly more beneficial to students possessing the formal reasoning skills necessary to investigate and develop hypotheses in scientific settings.

References

Bell, B. (1994). The effects of task, database and guidance on interaction in a goal-based scenario. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA. Evanston, IL: Northwestern University, The Institute for the Learning Sciences. (ERIC Document Reproduction Service No. ED 375 855)

Bell, B., Bareiss, R., & Beckwith, R. (1993a, April). The role of anchored instruction in the design of a hypermedia science museum exhibit. Paper presented at the Conference of the American Education Research Association, Atlanta, GA. Evanston, IL: Northwestern University, The Institute for the Learning Sciences. (ERIC Document Reproduction Service No. ED 363 636)

Bell, B., Bareiss, R., & Beckwith, R. (1993b). Sickle cell counselor: A prototype goal based scenario for instruction in a museum environment. Journal of the Learning Sciences, 3(4), 347-386.

Bodner, G. M., & Guay, R. B. (1997). The Purdue visualization of rotations test. The Chemical Educator, 2(4), 1-18.

BouJaoude, S. B., & Giuliano, F. J. (1994). Relationships between achievement and selective variables in a chemistry course for nonmajors. School Science and Mathematics, 94(6), 296-302.

Cognition and Technology Group at Vanderbilt (CTGV). (1993). Anchored instruction and situated learning revisited. Educational Technology, 33(3), 52-70.

Ekstrom, R. B., French, J. W., Harman, H. H. , & Dermen, D. (1976). Manual for kit of factor-referenced cognitive tests. Princeton, NJ: Educational Testing Service.

Geban, O., Askar, P., & Ozkan, I. (1992). Effects of computer simulations and problem-solving approaches on high school students. Journal of Educational Research, 86(1), 5-10.

Harwood, W. S., & McMahon, M. M. (1997). Effects of integrated video media on student achievement and attitudes in high school chemistry. Journal of Research in Science Teaching, 34(6), 617-631.

Jackman, L. E., Moellenberg, W. P., & Brabson, G. D. (1987). Evaluation of three instructional methods for teaching general chemistry. Journal of Chemical Education, 64(9), 794-796.

Kolodner, J. L. (1993). Introduction. Journal of the Learning Sciences, 3(4), 303-304.

Lawson, A. E. (1983). Predicting science achievement: The role of developmental level, disembedding ability, mental capacity, prior knowledge, and beliefs. Journal of Research in Science Teaching, 20(2), 117-129.

Mitchell, A. , & Lawson, A. E. (1988). Predicting genetics achievement in nonmajors college biology. Journal of Research in Science Teaching, 25(1), 23-37.

Moore, C., Smith, S., & Avner, R. A. (1980). Facilitation of laboratory performance through CAI. Journal of Chemical Education, 57(3), 196-198.

Niaz, M., & Lawson, A. E. (1985). Balancing chemical equations: The role of developmental level and mental capacity. Journal of Research in Science Teaching, 22(1), 41-51.

Schank, R. C., & Cleary, C. (1995). Engines for education. Hillsdale, NJ: Lawrence Erlbaum Associates.

Schank, R. C., Fano, A., Bell, B., & Jona, M. (1993). The design of goal-based scenarios. Journal of the Learning Sciences, 3(4), 305-345.

Smith, S. G., & Jones, L. L. (1989). Images, imagination and chemical reality. Journal of Chemical Education, 66(1), 8-11.

Staver, J. R., & Jacks, T. (1988). The influence of cognitive reasoning level, cognitive restructuring ability, disembedding ability, working memory capacity, and prior knowledge on students' performance on balancing equations by inspection. Journal of Research in Science Teaching, 25(9), 763-775.

Tobin, K. G., & Capie, W. (1981). The development and validation of a group test of logical thinking. Educational and Psychological Measurement, 41(2), 413-423.

Zeitoun, H. H. (1988). The relationship between abstract concept achievement and prior knowledge, reasoning ability, and sex among some Egyptian secondary school students. Paper presented at the 61st Annual Meeting of the National Association for Research in Science Teaching, Lake of the Ozarks, MO. Egypt: University of Tanat. (ERIC Document Reproduction Service No. ED 292 636)

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